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QUASI-STATIC TENSILE STRESS-STRAIN CURVES--I, 2024-T3510 ALUMINUM ALLOY

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February 1976

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Young's modulus	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents results of quasi-static tensile tests of 2024-T3510 aluminum alloy rods performed at 22°C. The yield strengths, Poisson's ratio, and Young's modulus are reported.

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I. INTRODUCTION

The quasi-static tensile tests reported herein were conducted as part of the Core Materials Program of the Solid Mechanics Branch of the Terminal Ballistics Laboratory. The objective of this program is to characterize the mechanical behavior of armor and armor penetrators. This characterization should prove useful to designers of armored vehicles and projectiles and will provide valuable input data for computer codes that model penetration processes.

This report, the sixth[1-5*] in a series describing the results of the Core Materials Program, covers quasi-static tensile tests of 2024-T3510 aluminum alloy. The results include Young's modulus, Poisson's ratio, yield and fracture strengths, and an average stress-strain curve.

II. TEST PROCEDURES

The testing apparatus, procedures and data reduction regimen were generally the same as those previously reported for compression testing.[1] The test specimens were machined from one-inch diameter rods of commercial purity. Chemical analysis of a specimen of the rod is presented in Reference 4. Six test specimens with circular cross sections were prepared in accordance with ASTM[6] standard E 8, Figure 8. The specimen length was 82.51mm, gage diameter was 6.35 ± 0.05mm and gage length was approximately 55mm. The ends of the specimens were 12.7mm in diameter and were machined with an 18.5 degree taper down to the gage diameter. The six specimens were instrumented with pairs of high elongation transverse foil resistance-type strain gages. Four of the specimens were also instrumented with a 50 percent maximum strain extensometer (Instron Model G-51-12). These four specimens were pulled to fracture, and the remaining two were pulled until one of the foil strain gages failed. The strain rate for all the tests was 5×10^{-2} min^{-1}.

The average temperature for the tests was 21.9 ± 1°C with a relative humidity of 53 ± 3 percent.

III. RESULTS

The stress and strain at fracture are shown in Table I.

The average engineering stress-strain curve taken to a strain of 1.2 percent, as determined from six specimens instrumented with foil strain gages, is presented in Figure 1. The vertical error bars in Figure 1 indicate plus and minus one standard deviation in the stress. The average engineering stress-strain curve taken to fracture, as calculated from the

*References are listed on Page 11.

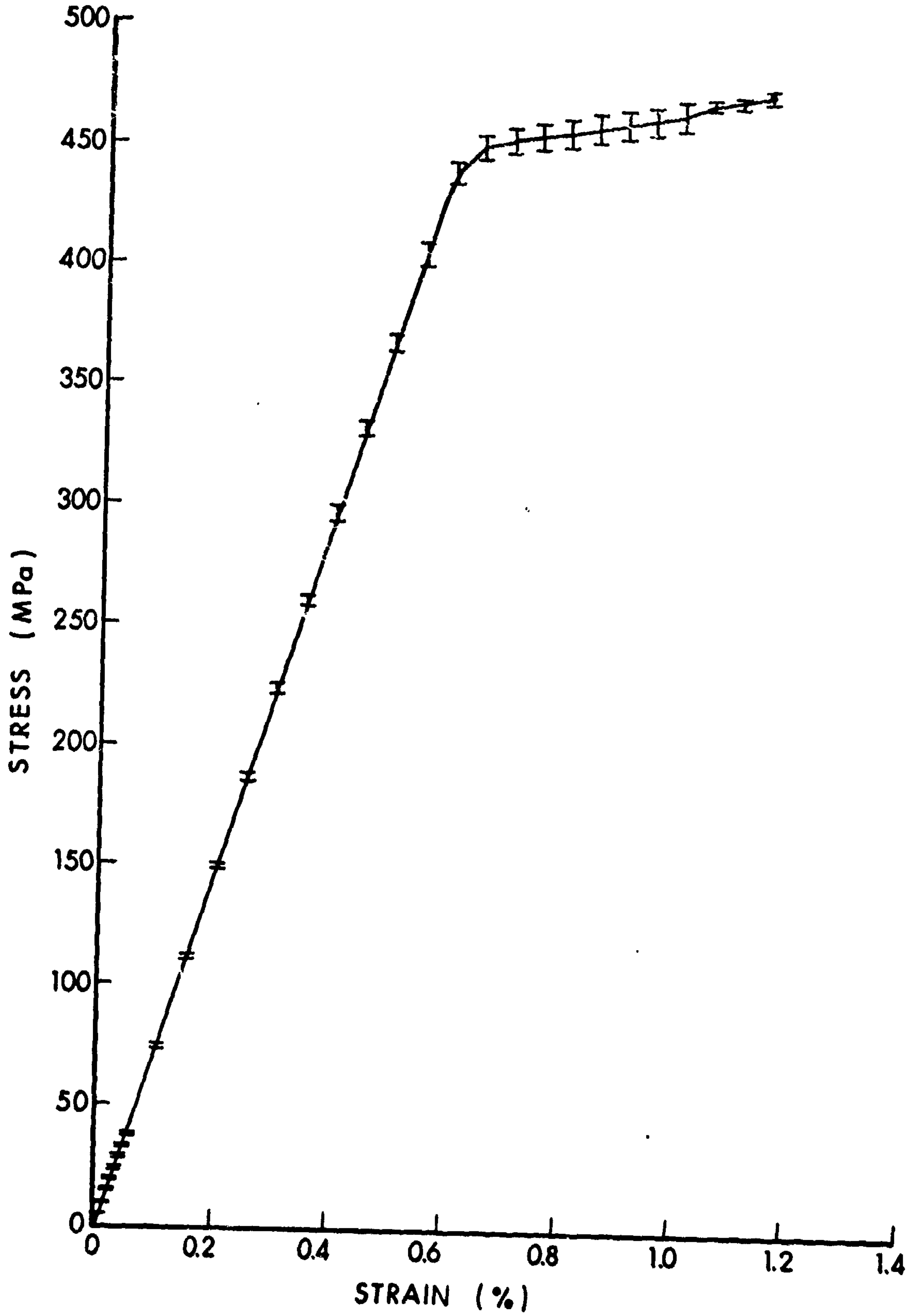

Figure 1. Average Engineering Stress - Strain Curve for Tensile Test of 2024-T3510 Aluminum Alloy.

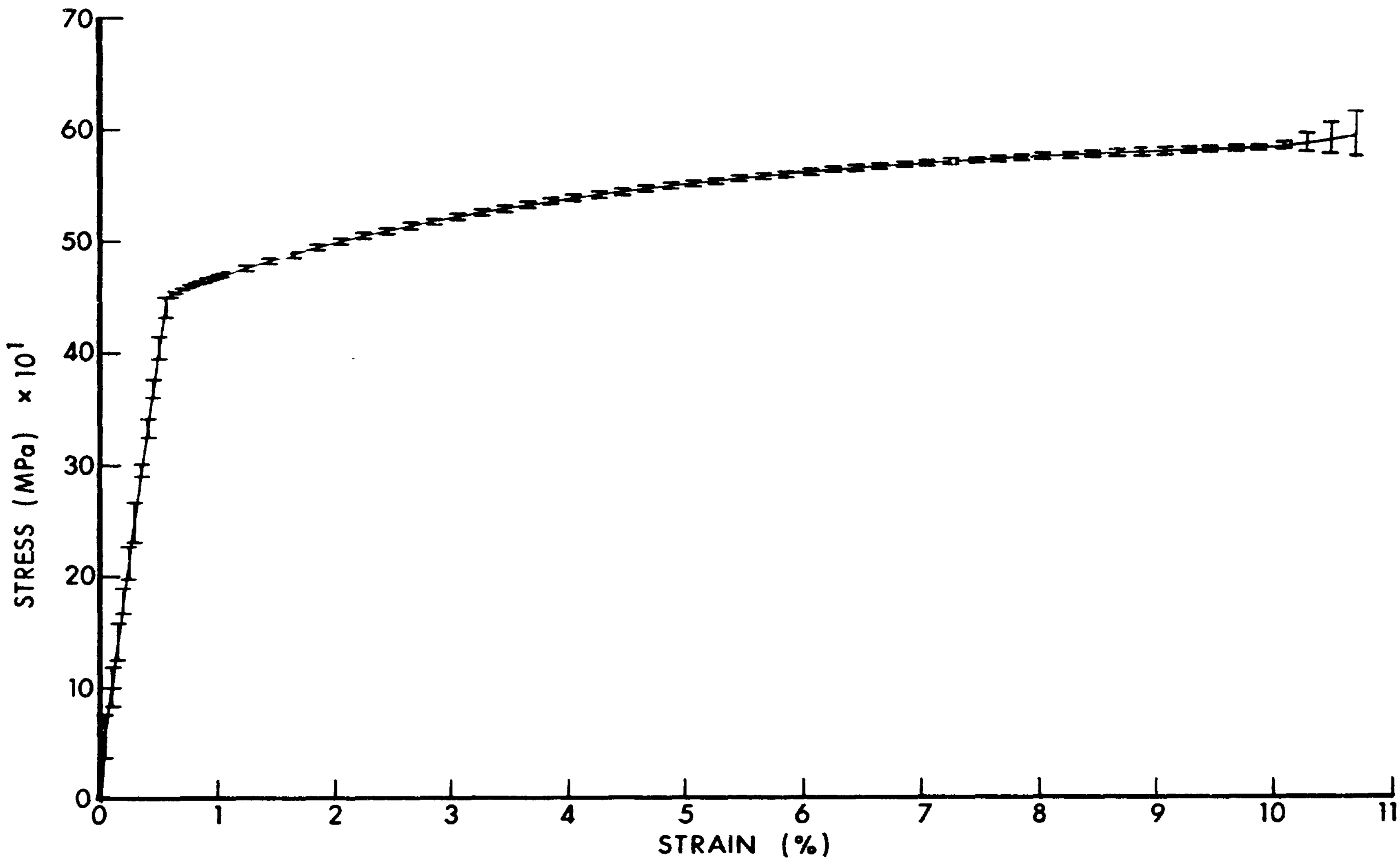

Figure 2. Average Engineering Stress-Strain Curve for Tensile Test up to Fracture for 2024-T3510 Aluminum Alloy.

extensometer data on four specimens, is shown in Figure 2. The error bars are again plus and minus one standard deviation in the stress.

Poisson's ratio as a function of strain for specimen 2 is presented in Figure 3. This curve is representative of all six specimens. Figure 3 also includes an apparent Poisson's ratio as calculated from the following expression (for derivation of this expression see Reference 4).

$$\nu_{apparent} = \frac{\hat{\sigma}}{\epsilon_{xx}(\hat{\sigma})}\left(\frac{\nu_{\epsilon} - 1/2}{E}\right) + 1/2$$

where

$\nu_{apparent}$ = Poisson's ratio in plastic region

$\hat{\sigma}$ = Stress

$\epsilon_{xx}(\hat{\sigma})$ = Strain at $(\hat{\sigma})$ stress

ν_{ϵ} = Poisson ratio determined from static tests via extrapolation to zero strain.

E = Young's modulus determined from static test via "best fit" in linear elastic region.

The average yield strength, Young's modulus and Poisson's ratio are presented in Table II. Table II also includes results from quasi-static compression tests[4] and results from sonic measurement tests[5] of 2024-T3510. All the specimens for these three series of tests came from the same heat of 2024-T3510 aluminum alloy.

IV. CONCLUSIONS

A series of quasi-static tensile tests have been completed on 2024-T3510 aluminum alloy. The data acquired from these tests have been reduced and compare favorably with similar results obtained by two different techniques.

It is concluded from the reproducibility of the data that the results presented are an accurate partial description of the elastic and plastic properties of 2024-T3510 aluminum alloy.

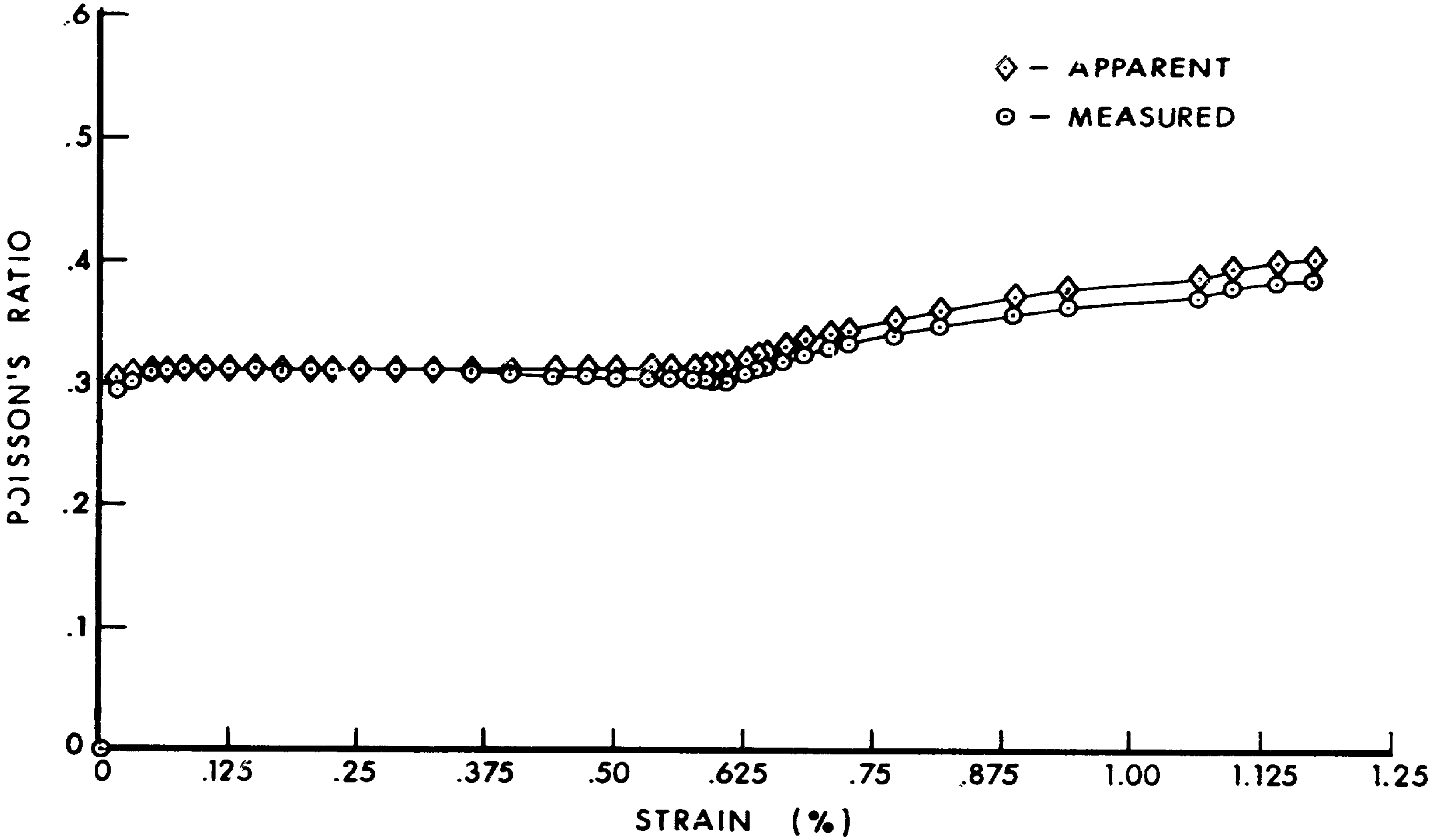

Figure 3. Poisson's Ratio as a Function of Strain for Tensile Test of 2024-3510 Aluminum Alloy.

TABLE I

STRESS AND STRAIN AT FRACTURE

Specimen	Stress at Fracture	Strain at Fracture
	MPa	%
1	582.9	10.61
2	581.5	10.64
3	587.3	11.31
4	580.6	9.94

TABLE II

MATERIAL PROPERTIES OF 2024-T3510 ALUMINUM ALLOY[a]

Property	Results of Tensile Testing[b]	Results of Compression Testing[4]	Results of Sonic Testing[5]
Young's Modulus, GPa	74.62 (0.36)	76.1	75.20
Yield Strength, MPa (0.2%)	457.2 (3.8)	444.	-----
Poisson's Ratio	0.313 (0.006)	0.321	0.313

[a]Hardness for this material was 148 BHN.

[b]The value within the parentheses is one standard deviation.

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